INL/CON-23-72826-Revision-2

A New Approach to Monitoring Solvent Extraction Processes for the Nuclear Industry

November 2023

Edna S Cardenas, Luis A Ocampo Giraldo, Mitchell Greenhalgh, Jay D Hix, Cody McBroom Walker, Katherine Neis Wilsdon, James T Johnson

Changing the World's Energy Future

Idaho National Laboratory

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Prepared for the
U.S. Department of Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517

November 14, 2023

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A New Approach to Monitoring Solvent Extraction Processes for the Nuclear Industry

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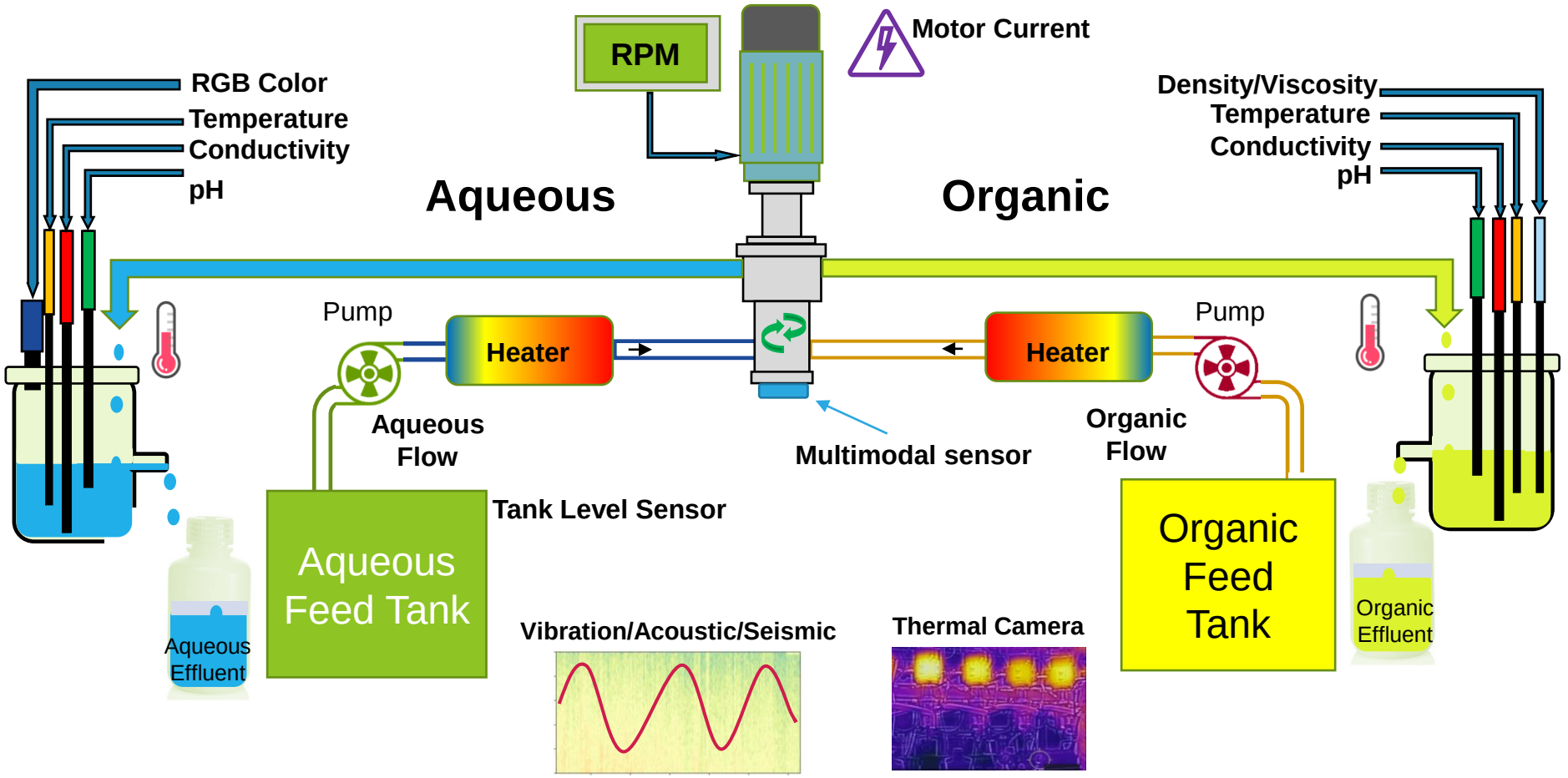
Supported to Inform in Design of INL's Beartooth Testbed

- Infrastructure includes glove box lines, dissolution equipment, and solvent extraction equipment.
- Solvent extraction flowsheets
  - Extraction, scrub, strip, solvent reconditioning
- A highly configurable testbed that will accommodate numerous flowsheets by changing line inlets and outlets.
  - PUREX, UREX, THOREX, etc.

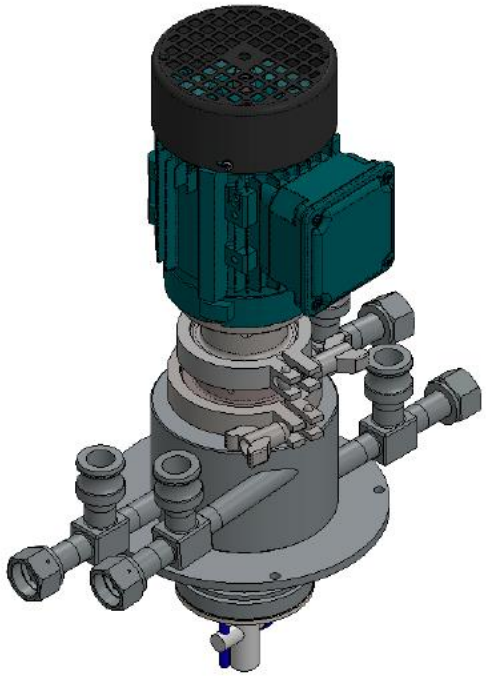
- Test novel separation methods.
- Train early-career separation scientists.
- Incorporate novel monitoring techniques.

Non-traditional Sensors



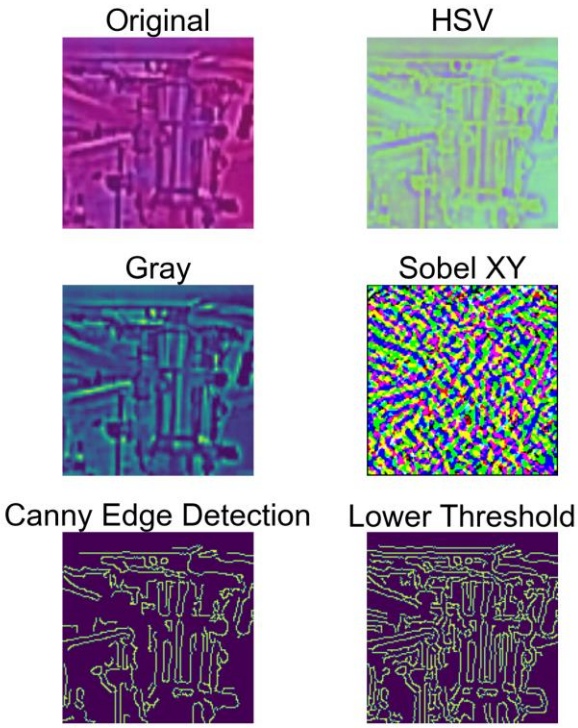
Novel Monitoring

- Can data be used to improve extraction process?
- Can data be used to predict equipment failure?
- Can data validate current sensor measurements?
- Can data be used in development of a digital twin?

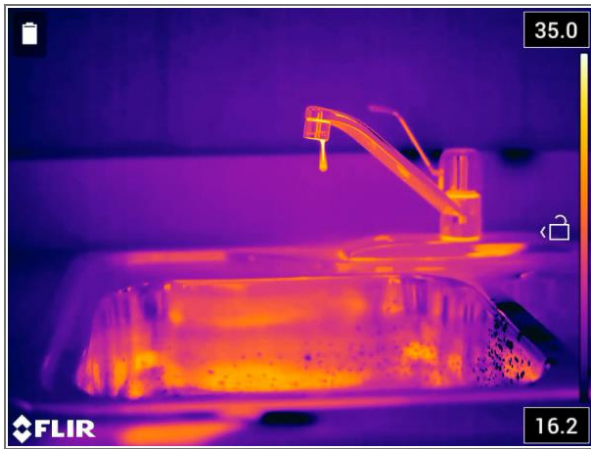


Thermal Camera Measurements for Leak Detection

- Develop model to alert process operators of a leak event.
- Data augmentation was used to generate new images and improve model robustness:
  - Shear, Zoom, Flip, and image modification techniques



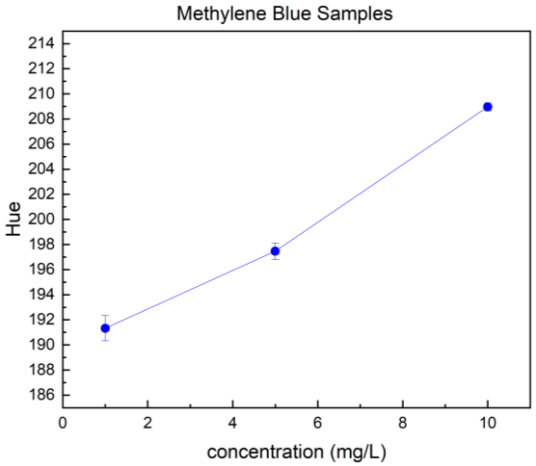
Performed Purposeful Leaks

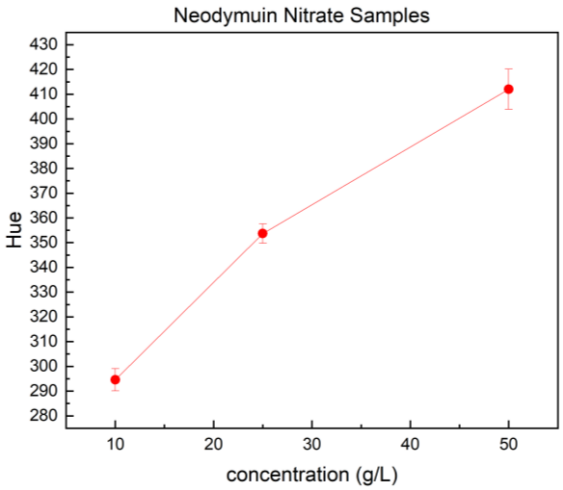


- Three different angles.
- Three different leak sizes.
- Three different leak locations.
  - contactor system
  - common sink

Relationship of Color to Concentration

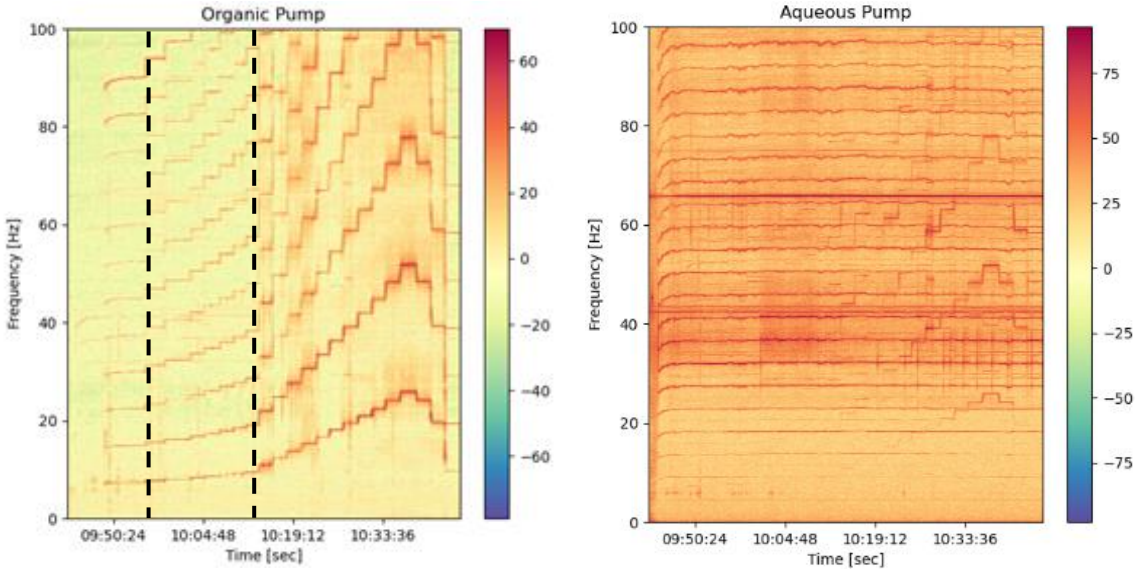
- Ran a series of experiments:
  - Solutions of known concentrations.
    - Blue, pink, yellow
  - Measurements taken with Red-Green-Blue color sensor.





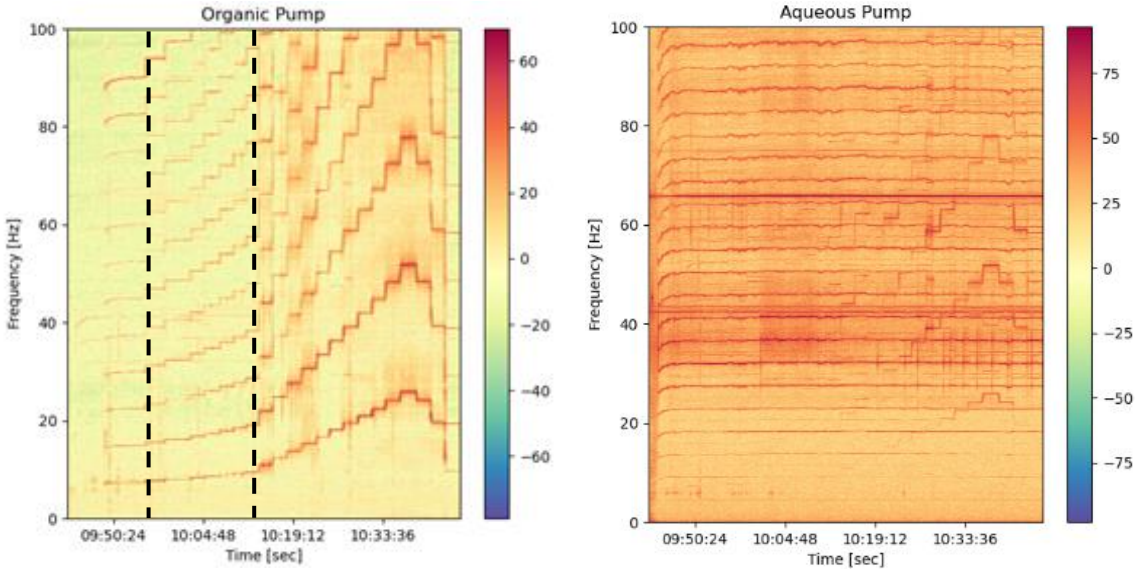
Vibration Measurements to Determine O to A

- Set the aqueous pump to a constant flow rate or 16.5%
- Set the organic pump to 28%, then increased in 1% increments, finally increased in 5% increments
- The ratio of frequencies approximately matched the ratio of flow rates.
  - Initially:
    - 28%/16.5%=1.7
    - 7.5/4.6=1.6
  - At maximum:
    - 90%/16.5%=5.5
    - 26/4.6=5.7

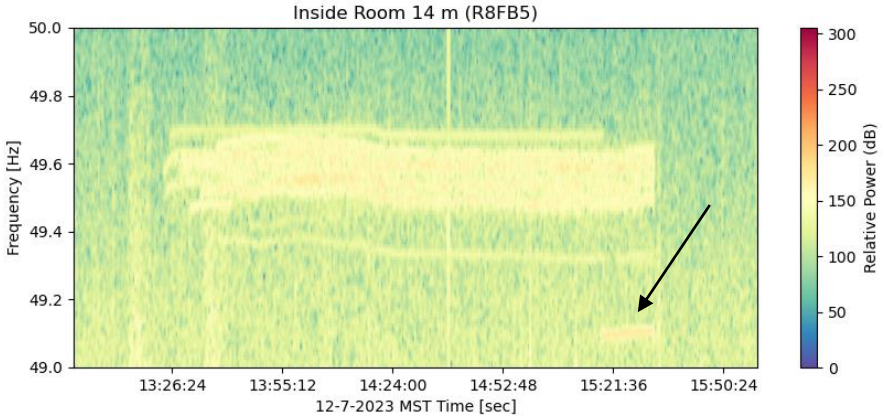


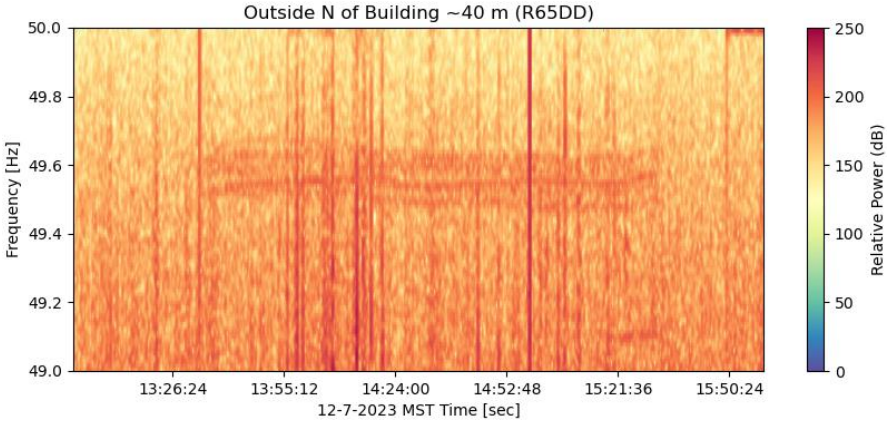
Power spectra slide

- Skeleton slide



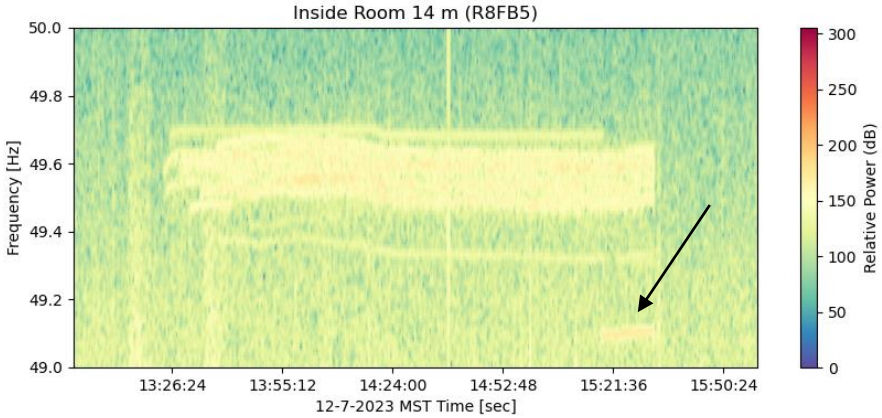
Acoustic Measurements Showing Rate of Contactor Motors

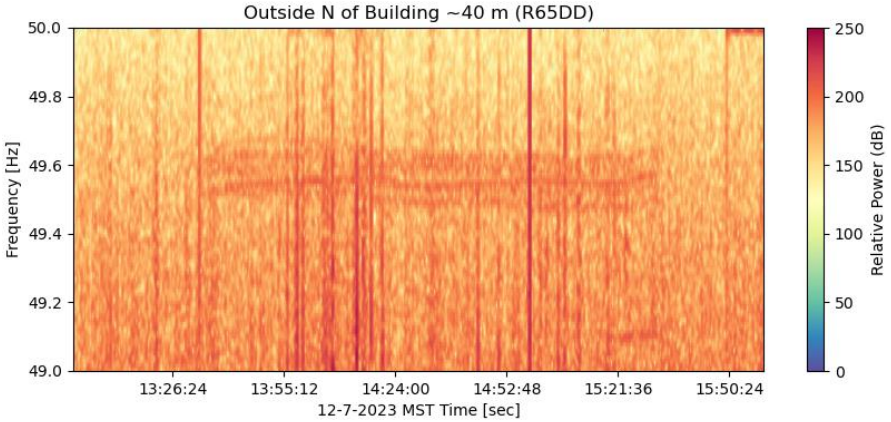




- Contactor motors were turned on one by one initially and then operated for approximately two hours.
- At around 15:19 the rate of operation of contactor 2 was changed from 3000 to 2940 RPM.
- Spectrogram on left - sensor in room ~14 m from contactor 1
- Spectrogram on right – sensor outdoors ~40 m from contactor 1, signal propagated through 4 walls.

Another RPM slide

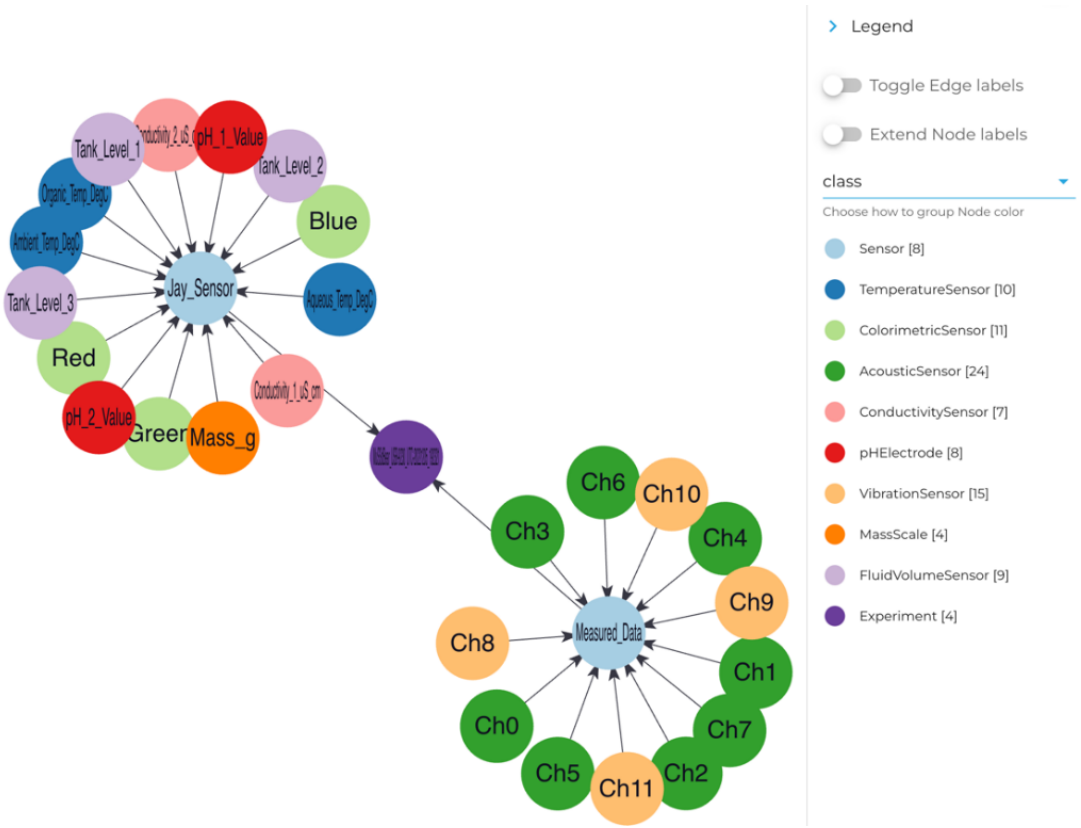




- Skeleton slide

Data Integration into Deep Lynx

- Began storing a portion of data into INL's data warehouse.
- Nodes are sensors.
- Edges are relationships.
- 8 of 11 datasets have been ingested.



Conclusions

- Use of thermal camera
- Vibration sensors
- Color sensor
- Acoustic sensors

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